SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 2001 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT   **MISSION COMMUNICATIONS SERVICES**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 1999 OPLAN 12/23/99	FY 2000 OPLAN REVISED	FY 2001 PRES BUDGET	Page Number
		(Thousands of Dollars)		
Ground Networks	211,200	162,000	--	SAT 5-4
Mission Control and Data Systems	143,100	233,800	--	SAT 5-11
Space Network Customer Services	25,700	10,500	--	SAT 5-21
Total	380,000	406,300	--	

Distribution of Program Amount by Installation

Johnson Space Center	119,700	171,900	--	
Kennedy Space Center	--	1,100	--	
Marshall Space Flight Center	300	1,400	--	
Dryden Space Flight Center	12,600	12,800	--	
Glenn Research Center	10,100	10,100	--	
Goddard Space Flight Center	101,800	71,800	--	
Jet Propulsion Laboratory	132,400	131,900	--	
Headquarters	3,100	5,300	--	
Total	380,000	406,300	--	

Note -- Beginning in FY 2001, funding for these activities will be moved to the Space Operations program under the Science, Aeronautics, and Technology Appropriation.

PROGRAM GOALS

The Mission Communications Services goal is to provide high quality, reliable, and cost effective space operations services which enable Enterprise mission operations. Reliable electronic communications are essential to the success of every NASA flight mission, from planetary spacecraft to the Space Transportation System (STS) to aeronautical flight tests.

The Space Operations Management Office (SOMO), located at the Johnson Space Center, in Houston, Texas manages the telecommunication, data processing, mission operations, and mission planning services needed to ensure the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner. The SOMO is committed to seeking and encouraging commercialization of NASA operations services and to participating with NASA's strategic enterprises in collaborative interagency, international, and commercial initiatives. As NASA's agent for space operations services, the SOMO seeks opportunities for using technology in pursuit of more cost-effective solutions, highly optimized designs of mission systems, and advancement of NASA's and the nation's best technological and commercial interests. The content described in this section represents the Mission Communications Services portion of the SOMO responsibilities.

The Mission Communications Services segment of NASA's Space Communications program is composed of Ground Networks, Mission Control and Data Systems, and Space Network Customer Service. These programs establish, operate, and maintain NASA ground networks, mission control, and data processing systems and facilities to provide communications service to a wide variety of flight programs. These include deep space and Earth-orbital spacecraft missions, research aircraft missions, and sub-orbital flights. Mission support services such as orbit and attitude determination, spacecraft navigation and maneuver support, mission planning and analysis and other mission services are provided. New communications techniques, standards, and technologies for the delivery of communication services to flight operations teams and scientific users are developed and applied. Agency spectrum management and data standards coordination for NASA are conducted under this program.

STRATEGY FOR ACHIEVING GOALS

The Space Operations program provides the necessary research and development to adapt emerging technologies to NASA communications and operational requirements. New coding and modulation techniques, antenna and transponder development, and automation applications are explored and, based on merit, demonstrated for application to future communications needs. NASA's flight programs are supported through the evaluation and coordination of data standards and communication frequencies to be used in the future.

The Space Operations program provides the necessary research and development to adapt emerging technologies to NASA communications and operational requirements. New coding and modulation techniques, antenna and transponder development, and automation applications are explored and, based on merit, demonstrated for application to future communications needs. NASA's flight programs are supported through the evaluation and coordination of data standards and communication frequencies to be used in the future.

Many science and exploration goals are achieved through inter-agency or international cooperation. NASA's Space Operations assets are provided through collaborative agreements with other U.S. Government agencies, commercial space

enterprises, academia, and international cooperative programs. Consistent with the National Space Policy, NASA procures commercially available goods and services to the fullest extent feasible, NASA develops selected technologies which leverage commercial investments and enable the use of existing and emerging commercial telecommunications services to meet NASA's Space Operations needs. These are all parts of the strategic approach to providing the vital communications systems and services common to all NASA programs and to achieve compatibility with future commercial satellite systems and services.

The Consolidated Space Operations Contract (CSOC) was successfully implemented on 1 January 1999 under the direction of the Space Operations Management Office and Lockheed Martin Space Operations Company as the Prime Contractor. CSOC provides end-to-end space operations mission and data services to both NASA and non-NASA customers. CSOC is a $3.44B contract with a Basic Period of Performance from January 1999 through December 2003 and an option period though December 2008. The contract is a Performance Based Cost Plus Award Fee (CPAF) with possible conversion to Fixed Price Incentive Fee (FPIF) within 2 years. A total of nine contracts were consolidated at the inception of CSOC, a further four contracts have been consolidated in FY 2000 to date and two further contracts are to be consolidated in FY 2001. CSOC reflects a significant change in NASA philosophy as accountability and day to day direction for providing space operations services shifts from NASA to the CSOC contractor.

Beginning in FY 2001, funding for these activities will be consolidated with Space Communication Services, currently part of the Mission Support appropriation, as the Space Operations program under the Science, Aeronautics, and Technology Appropriation. This is being done so as to link these activities more directly with the agency programs that constitute the principal users of these facilities and services. This will enable the Space Operations Management Office (SOMO) at Johnson Space Center to more effectively manage the Space Operations program. This will ensure that the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner. A set of budget crosswalk tables between the Space Communication Services and Mission Communications Service budget and the consolidated Space Operations program is described in the Special Issues section.

BASIS OF FY 2001 FUNDING REQUIREMENT

GROUND NETWORKS

	FY 1999	FY 2000	FY 2001
	(Thousands of Dollars)		
Deep Space Network – Systems	70,400	74,700	--
Deep Space Network – Operations..	53,800	53,300	--
Spaceflight Tracking and Data Network - Systems.............	1,000	300	--
Spaceflight Tracking and Data Network - Operations	7,700	3,600	--
Aeronautics, Balloons, and Sounding Rockets - Systems...	5,100	6,100	--
Aeronautics, Balloons, and Sounding Rockets - Operations	19,300	21,400	--
Total..	157,300	159,400	--

PROGRAM GOALS

The Ground Networks program goal is to provide high quality, reliable, cost-effective ground-based tracking, command and data acquisition systems and services for NASA science and aeronautics programs. Launch, emergency communications, and landing support for the Space Shuttle is also provided by the Ground Networks facilities. The program provides for the implementation, maintenance, and operation of the tracking and communications facilities necessary to fulfill program goals for the NASA flight projects. The Ground Networks program also supports NASA programs in collaborative interagency, international, and commercial enterprises and independently provides support to other national, international, and commercial enterprises on a reimbursable basis.

STRATEGY FOR ACHIEVING GOALS

The Ground Networks program is comprised of the following elements: the Deep Space Network (DSN), managed by the Jet Propulsion Laboratory (JPL); the Spaceflight Tracking and Data Network (STDN), managed by the Goddard Space Flight Center (GSFC); the Aeronautics, Balloon and Sounding Rocket (AB&SR) tracking and data acquisition facilities managed by GSFC/Wallops Flight Facility (WFF); and the Western Aeronautical Test Range (WATR), managed by the Dryden Flight Research Center (DFRC). As the prime contractor for the CSOC, the Lockheed-Martin Space Operations Company became responsible for providing space operational services beginning in January 1999.

Re-engineering efforts will continue on the STDN facilities, resulting in reduced operation and maintenance costs. NASA terminated S-band and C-band services at the Bermuda station in November 1998, following completion of two Space Shuttle modifications. One permits earlier communications through the Tracking and Data Relay Satellite (TDRS) during the launch phase of the mission and the second allows onboard use of the GPS to replace the use of ground radar for Space

Shuttle navigation. UHF Command services were terminated in FY 1999. The UHF air-to-ground voice service remains available for Space Shuttle launch operations.

The number of missions serviced by the DSN facilities and the requirements of the individual missions will increase dramatically over the next several years. In anticipation of the increases, new antenna systems have been developed and obsolete systems are expected to be phased out or converted for alternate uses. The DSN has been reconfigured with four new 34-meter antenna systems located at Goldstone, California; Canberra, Australia; and Madrid, Spain. These 34-meter antennas will enable the expanded coverage requirements and provide simultaneous coverage of two deep space missions that are in critical phases. Currently, a 34-meter antenna transferred from the U.S. Army located at Goldstone is supporting the Solar Observatory for Heliospheric Observations spacecraft. An 11-meter antenna system has been installed at each DSN complex to provide science support for the Institute of Space and Astronautical Science (ISAS) Japanese VLBI Space Operation Program (VSOP) spacecraft.

The DSN has several on-going re-engineering efforts. These new processes allow the DSN to increase the tracking hours delivered while reducing costs. The processes include giving a single operator end-to-end control of the entire data acquisition process, redesigning systems that provide support data to allow automation and quicken response time, developing a process to better define DSN services which will allow customers to choose only the services necessary to support the mission, and providing systems support data which allow greater automation and quicker response time.

The DSN is the premier facility for tracking deep space probes and is occasionally supplemented by the facilities of other agencies or nations. NASA is actively working with industry to foster the enhancement of existing "commercial-off-the-shelf" (COTS) data processing systems to expand their applicability so that inexpensive and reliable communications services can be readily obtained for the new small-class missions. Future earth orbiting missions will be supported by commercially available tracking systems, enabled by such tools as the Very Large Scale Integration (VLSI) High-Rate Frame Synchronization and Data Extraction chips which have been transferred to industry.

New Ground Networks capabilities include two 11-meter antenna systems installed near Fairbanks, Alaska and at Svalbard, Norway to provide command and data acquisition support for the expanded number of Earth-observing missions which includes EOS AM-1 and Landsat-7. Also, the Low Earth Orbit Terminal (LEO-T) contract has been expanded to provide three autonomous 5-meter ground stations for space science mission support. The first of these systems was installed in Puerto Rico and supported the Far Ultraviolet Spectroscopy Explorer (FUSE) mission in FY 1999.

The Ground Networks program, in conjunction with other NASA elements, is demonstrating and implementing Global Positioning System (GPS) flight units on NASA-sponsored missions. This demonstration seeks to minimize future tracking and navigation activities. The Student Nitric Oxide Explorer (SNOE) mission demonstrates these new capabilities using commercial flight units as the primary source of this function. The Western Aeronautical Test Range is striving for even more efficiency as it provides NASA's capability for tracking, data acquisition, and mission control for a wide variety of flight research vehicles. The WATR provides both on-orbit and landing support to the Space Shuttle and communications with the Mir Space Station. Intense planning is underway to support the Reusable Launch Vehicle (X-33) and other wide range of vehicles with WATR resources.

NASA will pursue commercial ground tracking services for low-Earth orbit missions. Transition activities to the commercial operator began in FY 1999. Upon successful completion of transition activities, the 26-meter subnet will be operated at a reduced level until FY 2001 in order to meet prior project support commitments. The DSN will return to servicing only deep space missions, highly elliptical Earth orbiting missions, launch and early orbit phase, ground-based radio astronomy, and planetary radar astronomy activities.

SCHEDULE AND OUTPUTS

	FY 1999 Plan	FY 1999 Actual	FY 2000 Plan	FY 2000 Current	FY 2001 Plan
Deep Space Network					
Number of NASA missions	52	46	51	45	--
Number of hours of service	92,000	93,000	84,000	84,000	--
Ground Network					
Number of Space Shuttle launches	7	4	8	4	--
Number of NASA/Other ELV launches	26	38	25	45	--
Number of NASA Earth-Orbiting missions	30	33	37	32	--
Number of Sounding Rocket deployments	30	25	25	27	--
Number of Balloon deployments (scientific)	26	26	26	26	--
Number of hours of service (GN Orbital Tracking)	23,750	26,000	25,200	23,000	--
Western Aeronautical Test Range					
Number of NASA missions	1,100	905	1,200	N/A	--
Number of NASA research flights	750	200	350	N/A	--
Number of Hours of Mission Control Center Support	N/A	N/A	1,450	1,450	

CONSOLIDATED SPACE OPERATIONS CONTRACT (CSOC)

Phase 1 Contract Award	May 1997
Phase 2 Proposal Due	January 1998
Phase 2 Contract Award	October 1998
Phase 2 Phase-In	October-December 1998
Phase 2 CSOC In Force	January 1999

The CSOC measures of performance apply to the Ground Networks, Mission Control Data Systems, and Space Network Customer Services.

ACCOMPLISHMENTS AND PLANS

The Deep Space Network (DSN) provided over 90,000 hours of tracking support to 49 missions during FY 1999. The year was unusually active with many critical events requiring support. These included 17 launches of NASA, NASA cooperative, and reimbursable spacecraft. The NASA support included the launches of DS1, MCO, MPL, Stardust, QuickSCAT, and the small explorers: SWAS, WIRE, and FUSE. The DSN also supported numerous encounters, including Galileo's continuing encounters with the moons of Jupiter, DS1's asteroid encounter, the Cassini Venus flyby and Earth swing-by, Planet-B Earth flyby, and the NEAR asteroid encounter. Special tracking coverage was provided more than 19 times in support of spacecraft emergencies and anomalies. Missions receiving this special support included DS1, MGS, Stardust, ACE, Galileo, NEAR, SOHO, TDRS, MPL, and GOES. During this busy year, DSN performance levels continued to exceed requirements, with delivery of scheduled telemetry data exceeding 98%.

JPL engineers worked with SOMO and its industry contract partners to ensure that the integrated operations architecture design will meet the needs of deep space missions while reducing life cycle costs. In particular, a new high-level control architecture was defined for the DSN. This new service-oriented Deep Space Missions System architecture was successfully applied to DS1, MGS, and Stardust.

JPL has also been working to decrease the Deep Space Network's complexity and improve equipment reliability, thereby enabling substantial DSN operations and maintenance cost savings. Efforts along these lines include Y2K certification, improved network control, network simplification, upgrades to the 26-meter antenna subnet, replacement of aging electronics systems, and decommissioning of obsolete antennas.

During FY 1999, over 400 program elements associated with the DSN were subjected to a rigorous Y2K certification process involving the examination of 8 million source lines of code within the DSN itself and another 8 million lines of code in the advanced multi-mission operations system.

Development of the Network Control Project (NCP) was mostly completed in FY 1999 with deployment scheduled to start during the first quarter of FY 2000. Deployment of NCP will facilitate workload reductions at the antenna stations and establish the infrastructure for modernization, automation, and reduction in operations cost.

The Network Simplification Project (NSP) has continued on schedule. NSP consolidates or replaces all the telemetry and radiometric DSN equipment with new technology and COTS solutions that enable advanced capabilities and remote operations. The objectives include replacing failure-prone aging assemblies, reducing system interfaces, reducing manual switches, replacing old NASA-unique protocols with industry standards, and providing new deep space mission command services to eliminate labor-intensive controller functions.

Major elements of the effort to replace aging DSN electronics include accelerated deployment of the Block V Exciters and the microwave controller. The new exciters replace 20-to-30 year old suites of uplink processing equipment -- increasing reliability, decreasing maintenance, and accommodating the pursuit of higher frequency, Ka-band communications. The microwave controller provides for computer control, allowing automation and reducing operations costs.

Implementation has begun on the telecommunications roadmap that was developed in FY 1998. The roadmap laid out a plan for using new technologies to increase the DSN's deep space communications capabilities to accommodate a growing exploration fleet while maximizing the utility of the existing DSN antennas. The first major goal of this implementation

will be the addition of Ka-band reception capability on all of the DSN's 34-meter beam wave-guide antennas. An implementation plan was developed in FY 1999 that has successfully passed a preliminary definition and cost review, and has moved on to prototyping activities for certain key technologies. One of these technologies currently under test is a single microwave feed horn and associated cryogenic low-noise amplifiers that can receive both X-band (8 GHz) and Ka-band (32 GHz) simultaneously. The other significant effort undertaken as part of the telecommunications roadmap is the completion of the DSS-26 34-meter antenna at Goldstone. The electronics for this antenna are being developed and installed to make this antenna operational in FY 2001.

Additional upgrades of the unique 70 meter antennas were made to avoid obsolescence issues and develop an improved transmit capability. The 70 meter X-band Uplink task will implement a higher power transmit capability to better communicate with spacecraft in the outer solar system. The 34-meter antenna-arraying task is also nearing completion. This task has already demonstrated the improved performance achievable through the use of an array of multiple antennas and will be operational in early FY 2000.

The Ground Network (GN) is comprised of tracking stations in Alaska, Bermuda, Merritt Island (MILA), McMurdo, and Wallops Island. The GN also supports critical Space Shuttle launch, emergency communications, and landing activities. The GN provides for the implementation, maintenance, and operation of the tracking and communications facilities necessary to fulfill program goals for flight projects in the NASA mission set. Missions supported also include NASA inter-agency collaborative programs, commercial enterprises, and other national, international, and commercial enterprises on a reimbursable basis. The Space Shuttle launches were successfully supported through dedicated facilities of the MILA station and the Ponce de Leon inlet annex. The continuation of this support, further enabled by the implementation of the re-engineered STDN system elements, is expected throughout FY 2000 and FY 2001.

The aging 9-meter hydraulic antennas at MILA are being replaced with electric drive systems, capable of functioning without an operator. Efforts in support of this initiative will begin in FY 2000 and be completed in FY 2001. Infusion of technology developed in support of receiver, exciter, and ranging subsystems will be introduced in a phased manner to replace aging subsystems at MILA and Ponce de Leon throughout FY 2000.

The Wallops Flight Facility (WFF) completed the installation of the 11-meter telemetry antenna systems at the Poker Flat Research Range near Fairbanks, Alaska and at Svalbard, Norway in preparation for support of the QuikSCAT and Landsat-7 missions in FY 1999. Ground station and network integration and certification testing was completed in FY 1999. The systems are scheduled to be officially transitioned to CSOC for operations, maintenance, logistics, and sustaining engineering in FY 2000. NASA is planning for the future of the McMurdo Ground Station (MGS) in Antarctica. The drivers for this station are the need to provide for predictable performance of MGS in support of Launch and Early Orbit Operations, to provide for supplemental Earth Observing System (EOS) Polar Ground Network (EPGN) support, and to pursue a mutually beneficial relationship with the U. S. Air Force with regard to improved service and cost sharing. Concept definition, project plans, and approval to proceed were granted in FY 1999. Upcoming plans for MGS in FY 2000 include the implementation of a Joint Operations Center (JOC) with the U. S. Air Force and subsystem upgrades in support of the EOS missions.

Work will continue on the replacement of the Wallops Range Data Acquisition and Computational System; this system is a range safety tool and is obsolete and expensive to maintain. Work on the 11-meter antenna system enhancements required to support the Advanced Earth Orbiting Satellite (ADEOS) II mission will be completed in FY 2001.

The Ka-Band Ground Terminal Development activity will begin in FY 2000. This effort will seek to demonstrate the commercial viability of providing high rate ground data acquisition in the Ka-Band area. This activity will include participation by members from various NASA centers and commercial vendors.

The NASA Dryden Flight Research Center (DFRC) Western Aeronautical Test Range (WATR) provides communications, tracking, data acquisition, and mission control for a wide variety of aeronautic and aerospace vehicles. The WATR meets widely diverse research project requirements with tracking, telemetry, and communication systems and control room complexes. Due to the nature of the aeronautical research mission, it is essential to respond to new project requirements within days or weeks rather than months or years, and to do so safely, efficiently, and economically. To accomplish this, WATR facilities, systems, and processes are designed to support a wide range of requirements, be easily reconfigured (less than one hour for control rooms), to be shared between multiple projects, and to readily interface with specialized equipment brought in by our customers. This approach provides the needed agility to be responsive while reducing costs to individual customers by increasing utilization rates. Customers of the WATR facilities include other NASA Centers, the U.S. Army, U.S. Air Force, U.S. Navy, Federal Aviation Administration, and the aerospace industry.

BASIS OF FY 2001 FUNDING REQUIREMENTS

MISSION CONTROL AND DATA SYSTEMS

	FY 1999	FY 2000	FY 2001
		(Thousands of Dollars)	
Mission Control - Systems...	10,000	9,700	--
Mission Control - Operations...	142,800	182,700	--
Data Processing - Systems...	42,900	41,000	--
Data Processing - Operations	17,300	8,600	--
Total..	213,000	242,000	--

PROGRAM GOALS

The Mission Control and Data Systems program goal is to provide high-quality, reliable, cost-effective mission control and data processing systems and services for spaceflight missions; data processing, and flight dynamics services for NASA flight projects. The program provides for data systems, telecommunications systems technology demonstrations, and coordination of data standards and communications frequency allocations for NASA flight systems. The Mission Control and Data Systems program provides for the launch and early orbit implementation, maintenance, and operation of the mission control and data processing facilities necessary to ensure the health and safety and the sustained level of high quality performance of NASA flight systems. The program provides and demonstrates key technologies and innovative approaches to satisfy Strategic Enterprises' mission needs and to maximize NASA's ability to acquire commercial services that meet its communications and operations needs. Through these efforts, the program also seeks to promote sustained U.S. economic and technological leadership in commercial communications.

STRATEGY FOR ACHIEVING GOALS

The Mission Control and Data Systems program, primarily managed by the GSFC, is comprised of a diverse set of facilities, systems and services necessary to support NASA flight projects. The Lockheed Martin Space Operations Company was awarded the Consolidated space Operations Contract (CSOC) and became the primary contract responsible for systems engineering, software development and maintenance, operations, and analytical services beginning in January 1999.

The mission control function consists of planning scientific observations and preparing command sequences for transmission to spacecraft to control all spacecraft activities. Mission Operations Centers (MOC's) interface with flight dynamics and communications network, and science operations facilities in preparation of command sequences, perform the real-time uplink of command sequences to the spacecraft systems, and monitor the spacecraft and instrument telemetry for health, safety, and system performance. Real-time management of information from spacecraft systems is crucial for rapid determination of the condition of the spacecraft and scientific instruments and to prepare commands in response to emergencies and other unplanned events, such as targets of opportunity.

Mission control facilities operated and sustained under this program are Mission Operation Centers (MOCs) for the Hubble Space Telescope (HST) program; the International Solar Terrestrial Physics (ISTP) Wind, Polar, and Solar Observatory for Heliospheric Observation (SOHO); Rossi X-ray Timing Explorer (RXTE), TOMS-Earth Probe (EP), Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX); Fast Auroral Snapshot (FAST); Transport Region and Coronal Explorer (TRACE); and Submillimeter Wave Astronomy Satellite (SWAS) missions, and the Multi-satellite Operations Control Center (MSOCC) which supports the Compton Gamma Ray Observatory (CGRO), Upper Atmosphere Research Satellite (UARS), Extreme Ultraviolet Explorer (EUVE), and Earth Radiation Budget Satellite (ERBS) missions. The Advanced Composition Explorer (ACE) and Tropical Rainfall Measurement Mission (TRMM) are also operated out of GSFC MOC's. Data processing support is provided for the ISTP/Geomagnetic Tail (Geotail) and Extreme Ultraviolet Explorer (EUVE) missions.

The CGRO has phased into the TPOCC architecture of distributed workstations first used for the International Monitoring Platform (IMP-8) mission. NASA's SAMPEX, FAST, and Submillimeter Wave Astronomy Satellite (SWAS) missions will be operated from a common control facility for Small Explorer missions. The SWAS Mission Operations Center has been completed. The Wide Field Infrared Explorer (WIRE) control center has also been completed. These workstation systems will allow for increased mission control capability at reduced cost.

The first launch of a Medium-class Explorer (MIDEX) is currently scheduled for January 2000. Approximately one spacecraft per year will be launched, with potentially every other MIDEX mission operated from GSFC, dependent on successful Principal Investigator teaming arrangements. To minimize operations costs, plans for the MIDEX missions include consolidating the spacecraft operations, flight dynamics and science data processing all into a single multi-mission control center. Many of the functions will be automated using a commercial expert system product. The control center system will be used for spacecraft integration and test, thereby eliminating the need and cost of unique spacecraft manufacturers integration and test systems.

Other mission control systems include the Space Shuttle Payload Operations Control Center (POCC) Interface Facility and the Command Management System. The Space Shuttle POCC Interface Facility (SPIF) is being upgraded with a low-cost, PC-based front-end data system now operating in shadow mode. The SPIF provides a single interface to the Mission Control Center for use of spacecraft mission control facilities to access spacecraft deployed by the Space Shuttle. The Command Management System generates command sequences to be used by mission control centers. A User Planning System, currently being upgraded to a workstation-based environment compatible with the Network Control Center (NCC) configuration, is provided for scheduling communications with spacecraft supported by the Tracking and Data Relay Satellite System (TDRSS); and the Flight-to-Ground Interface Engineering Center provides flight software pre-flight and in-flight simulation and development support for GSFC flight systems. An Operations Support Center maintains status records of in-flight NASA systems.

The data processing function captures spacecraft data received on the ground, verifies the quantity and quality of the data and prepares data sets ready for scientific analysis. The data processing facilities perform the first order of processing of spacecraft data prior to its distribution to science operations centers and to individual instrument managers and research teams.

Data processing facilities include the Packet Data Processing (PACOR) facility, the Data Distribution Facility, and the Telemetry Processing Facility. The PACOR facility utilizes the international Consultative Committee for Space Data Systems data protocol to facilitate a standardized method of supporting multiple spacecraft. PACOR provides a cost-effective means of processing flight data from SAMPEX, EUVE, CGRO, SOHO, SWAS, RXTE, TRMM, and HST spacecraft missions. The transfer of EUVE to the University of California at Berkley in FY 1998 and the relocation of CGRO processing to the workstation-based PACOR II in FY 1998 resulted in the closure of the older PACOR I system.

The Data Distribution Facility (DDF) performs electronic and physical media distribution of NASA space flight data to the science community. The DDF has been a pioneer in the use of Compact Disk-Read Only Memory technology for the distribution of spacecraft data to a large number of NASA customers. Specialized data processing services are provided by the Telemetry Processing Facility for the ISTP missions (Wind, Polar, and Geotail). The Spacelab Data Processing Facility located at the MSFC, processes data from Space Shuttle payloads. Specialized telemetry processing systems for NASA's Space Network is also provided under this program.

The Mission Control and Data Systems program provides for the operation, sustainment, and improvement of NASA's Flight Dynamics Facility (FDF). Funding for the FDF is used to: provide orbit and attitude determination for operating NASA space flight systems, including the Tracking and Data Relay Satellite (TDRS) and the Space Shuttle; develop high-level operations concepts for future space flight systems; modify existing FDF systems to accommodate future missions; develop mission-unique attitude software and simulator systems for specific flight systems; generate star catalogues for general use; and conduct special studies of future orbit and attitude flight and ground system applications. It is critical to continuously know the location of spacecraft so as to communicate with the system and to know the orientation of the spacecraft to assess spacecraft health and safety and to perform accurate scientific observations. The type and level of support required by spacecraft systems is dependent on the design of its on-board attitude and control systems, including its maneuver capabilities, and the level of position and pointing accuracy required of the spacecraft. Automated orbit determination systems for TDRS and other spacecraft systems are also under development.

Besides the operation of currently deployed spacecraft and the modification and development of mission control and data processing systems to accommodate new flight systems, the program also supports the study of future flight missions and ground system approaches. Mission control and first-order data processing systems are less costly systems. Yet, proper economy of mission planning requires solutions that integrate ground and flight system development considerations. Special emphasis is given by the Mission Control and Data Systems program to seeking integrated solutions to spacecraft and ground systems designs that emphasize spacecraft autonomy; higher data transmission and processing rates; ease and low cost of operation; reuse of software; and selected use of advanced hardware and software design techniques to increase the return of space flight system investments at equal or lower cost than is required to support today's mission systems.

The Mission Control and Data Systems program supports advanced technology development at GSFC, JPL and GRC. The GSFC team, including contractors and universities, provides advanced technology in several area such as tracking and data acquisition future systems, communications and telemetry transport, and advanced space systems for users. Anticipating a future mission set characterized by large numbers of rapid, low-cost missions, the JPL team invests in technologies that can increase the overall capacity-to-cost ratio for the Deep Space Network. Efforts are focused on core technologies unique to, and critical for, deep space telecommunications, tracking and navigation, and radio science. Current technology areas include antenna systems, low noise systems, frequency and timing, radio metric tracking, navigation, network automation,

atmospheric propagation and optical communications. The Glenn Research Center team identifies, develops, and demonstrates advanced radio frequency antennas, amplifiers, receivers, digital communications and hybrid network technologies and services for use in NASA missions and commercial systems.

The Mission Communication Services advanced technology development has three forms that include near term (1-3 years) demonstration and application of data management and telecommunications technology and procedures, mid-range (3-5 years) development of ground and space flight communications systems; and a long-term, pre-competitive technology development and demonstration make up. Consideration of innovative applications of commercial "off-the-shelf" (COTS) technology is emphasized. Such applications often open new market opportunities to suppliers of these technologies resulting from their NASA experience. Additionally, in response to White House National Space Policy, NASA is planning to transition its communications operations to commercial services. Technology developments and demonstrations focus on technology and service gaps to enable utilization of commercially provided services.

A critical element of the Mission Control and Data Systems program is the securing of adequate frequency spectrum resources which are required in the performance of all flight missions, piloted and unpiloted, including spectrum for all active emitters as well as passive sensors. GRC, in concert with NASA Headquarters Office of Space Flight, manages these resources for the Agency and coordinates frequency spectrum requirements with other federal agencies, industry and regulatory bodies to obtain all requisite authorizations to operate telecommunications systems associated with NASA programs. Consistent with its charter pursuant to both the Space Act of 1958 and the Communications Satellite Act of 1962, NASA also serves, as an advocate for obtaining the unique frequency spectrum allocations required by the commercial sector to exploit satellite technology for future generation telecommunications systems. In compliance with the 1992 Telecommunications Authorization Act, NASA actively participates in the Interdepartment Radio Advisory Committee to establish National and International spectrum management policies.

SCHEDULE AND OUTPUTS

	FY 1999 Plan	FY 1999 Actual	FY 2000 Plan	FY 2000 Current	FY 2001 Plan
Number of NASA spacecraft supported by GSFC mission control facilities	22	25	23	25	--
Number of mission control hours of service (thousands)	66,000	57,300	67,000	62,000	--
Number of billions of bits of data processed	64,500	N/A	67,000	N/A	--
Number of NASA/Other missions provided flight dynamics services	44	47	49	49	--
Number of NASA/Other ELV launches supported by flight dynamics services	34	37	22	22	--

ACCOMPLISHMENTS AND PLANS

Mission control facilities operated and sustained under this program are Mission Operation Centers (MOC) for the Hubble Space Telescope (HST) program; the International Solar Terrestrial Physics (ISTP) Wind, Polar, and Solar Observatory for Heliospheric Observation (SOHO); Rossi X-ray Timing Explorer (RXTE), Total Ozone Mapping Satellite-Earth Probe (EP), Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX); Transport Region and Coronal Explorer (TRACE); the Compton Gamma Ray Observatory (CGRO); and Submillimeter Wave Astronomy Satellite (SWAS) missions, and the Multi-satellite Operations Control Center (MSOCC) which supports Upper Atmosphere Research Satellite (UARS) and Earth Radiation Budget Satellite (ERBS) missions. The Advanced Composition Explorer (ACE), Tropical Rainfall Measurement Mission (TRMM), the International Monitoring Platform (IMP-8), and Land Satellite (Landsat-7) are also operated out of GSFC MOCs. Data processing support is provided for the ISTP/Geomagnetic Tail (Geotail) mission. Mission control of the Fast Auroral Snapshot (FAST) mission was operated under CSOC during FY 1999 and transitioned to the UCB beginning FY 2000. The path finder success of the earlier transition of EUVE mission operations was the basis for the FAST transition.

The data processing function captures spacecraft data received on the ground, verifies the quantity and quality of the data and prepares data sets ready for scientific analysis. The data processing facilities perform the first order of processing of spacecraft data (Level 0) prior to its distribution to science operations centers and to individual instrument managers and research teams.

Flight dynamics services were provided to all NASA space flight missions that utilize NASA's Space Network and to selected elements of the Ground Network, including the Space Shuttle, Expendable Launch Vehicles, and satellite systems. Attitude software and simulator development was provided for the TRACE, ACE, and TRMM flight systems.

The Mission Control and Data Processing area has pursued proactive measures to consolidate functions, close marginal facilities, and reduce overall contractor workforce to reflect the Agency's goals. Examples include the transition of both the SAMPEX and FAST MOC operations to ITOS workstation systems and the outsourcing of FAST mission operations to the UCB, the completion of the ISTP Reengineering consolidation of Wind and Polar operations with SOHO to be completed in FY 2000, and the use of automation to monitor routine spacecraft health and safety functions to enable smaller flight operations teams and reduced operations schedules (RXTE, CGRO, Landsat-7, etc.).

Transfer of data systems technologies to flight project use occurred in the areas of software reuse, expert system monitoring and command of spacecraft functions, and packet data processing systems. Software reuse, expert systems, workstation environments, and object-oriented language applications continued. The Mission Control and Data Systems upgrades areas will continue to integrate modern technology into mission operations support systems through the use of systems like the GenSAA for automation, software-based telemetry front-end processing systems and the Mission Operations Planning and Scheduling System, case-based and model-based reasoning tools, and commercial orbit planning systems.

Significant development, test, and pre-launch support associated with the MIDEX and SMEX missions are part of the Mission Control and Data Systems activity. Emphasis upon commercial products, artificial intelligence applications and advanced graphical displays will be continued in FY 2000 for application in MIDEX and future SMEX missions. Evolution of systems to a single integrated mission control, command management, flight dynamics, and first-level science processing system will continue. The Flight Dynamics Facility (FDF) operations concept to perform routine operations as integral functions within mission control centers will also continue into FY 2000. New flight dynamics technology development and infusion for autonomous space and/or ground spacecraft navigation and control will be major efforts.

Preparations for the HST Third Servicing Mission in FY 2000 will continue, including the delivery of the Vision 2000 ground system, delivery of the new flight control computer flight software, and the payload computer ACS support system. Development efforts will continue in preparation for the MIDEX MAP mission that is scheduled to launch in FY 2001.

The Mission Operations and Data Systems upgrades efforts will continue to focus efforts on operations automation beyond the RXTE Automated Mission Operations System (AMOS), the CGRO Reduced Operations by Optimizing Tasks and Technologies (ROBOTT), and the automation provided for TRACE to promote single shift staffing for operations. Mission Control and Data Systems will actively lead and participate in establishing new architecture directions and rapid prototyping, exploring system autonomy concepts, and use of commercial-off-the-shelf products.

Mission Control and Data Systems upgrades area will continue the lead in scoping and prototyping innovative architectures such as: the use of Transmission Control Protocol/Internet Protocol or Space Communications Protocol Standards for ground and flight communications; the use of knowledge-based control languages; ground and space autonomy; and active endorsement and collaboration in formulating a Space Objects technology for adoption and implementation of plug-and-play components for mission operations. Exploration of the promise of advanced communications technologies will continue throughout this period.

Development for Triana and MAP will be completed in FY 2001; developments will continue for the MIDEX and SMEX series as well as for the HST Servicing Mission 3B. Development efforts on Triana, MAP, EO-1, and similar missions will realize benefits from modern technology, commercial products, and more cost-effective processes (for example, a single system to perform spacecraft integration and test and mission operations; skunkworks development teams; concurrent engineering).

The flight dynamics work will continue to be provided in the areas of ground support system development, analysis, and automation tools.

BASIS OF FY 2001 FUNDING REQUIREMENT

SPACE NETWORK CUSTOMER SERVICES

	FY 1999	FY 2000	FY 2001
	(Thousands of Dollars)		
Space Network Customer Services......................................	9,700	4,900	--

PROGRAM GOALS

The goal of the Space Network Customer Service program is to provide high quality, reliable, cost-effective customer access to the multi-mission space telecommunications network serving all TDRS-compatible Earth orbiting and suborbital flight missions and to provide network control and scheduling services to customers of both the Space Network and selected Ground Networks elements.

STRATEGY FOR ACHIEVING GOALS

This program develops and maintains both the management and technical interfaces for customers for the Space Network. The Network Control Center (NCC), located at the Goddard Space Flight Center in Maryland, is the primary interface for all customer missions. The primary function of the NCC is to provide scheduling for customer mission services. In addition the NCC generates and transmits configuration control messages to the network's ground terminals and TDRS satellites and provides fault isolation services for the network. The Customer Services program also provides comprehensive mission planning, user communications systems analysis, mission analysis, network loading analysis, and other customer services and tests to insure network readiness and technical compatibility for in-flight communications.

The Lockheed Martin Space Operations Company was recently awarded the Consolidated Space Operations Contract (CSOC) and will be the primary contractor responsible for systems engineering, software development and maintenance, operations, and analytical services beginning in January 1999.

The Customer Services program also undertakes network adaptations to meet specific user needs and provides assistance to test and demonstrate emerging technologies and communications techniques. A low power, portable transmit/receive terminal, called Portcom, which operates with TDRS spacecraft has been demonstrated. Potential applications include data collection from remote sites where commercial capabilities do not exist, such as NOAA ocean research buoys and National Science Foundation (NSF) Antarctic activities. A series of tests are being conducted with Japanese and European satellites and data acquisition communications systems for mutual provision of emergency operational spacecraft support.

SCHEDULE AND OUTPUTS

	FY 1999 Plan	FY 1999 Actual	FY 2000 Plan	FY 2000 Current	FY 2001 Plan
Number of NASA spacecraft events supported by the NCC	99,900	N/A	100,800	N/A	--

ACCOMPLISHMENTS AND PLANS

Implementation was completed on an improved, distributed architecture for the NCC, which is Year 2000 (Y2K) compliant. This Service Planning Segment Replacement (SPSR), provides more efficient use of the network capabilities, improved ability to resolve scheduling conflicts among customer missions, and provides standard commercial protocols for both internal and customer interfaces. The NCC modifications to the scheduling system also incorporated the Request Oriented Scheduling Engine (ROSE) which provides special features for conflict-free spacecraft scheduling, such as goal-directed scheduling and repetitive activities with variable start times and duration. This architectural change was undertaken over several years and accomplished segment by segment. The Communication and Control Segment Replacement (CCSR) development effort, planned as a follow on to the SPSR, was cancelled when analysis indicated that it would not be cost effective in the current environment. Work will be initiated in FY 2000 on various components of the DAS, including Space Network Web-based scheduling; this effort is expected to continue through FY 2001 and become fully operational in FY 2002.

The Ka-Band Ground Terminal Development activity will begin in FY 2000. This effort will seek to demonstrate the commercial viability of providing high rate ground data acquisition in the Ka-Band area. This activity will include participation by members from various NASA centers and commercial vendors. The successful demonstration of this capability is scheduled for late FY 2001. Capabilities to be demonstrated are far beyond what is in operation today. Success will allow NASA and its commercial partners to take advantage of the new frequency allocations for space and earth science and to alleviate issues regarding radio frequency spectrum interference that exist today.

The requested funding also provides for continuation of mission planning, customer requirements definition and documentation, mission and network operational integration, analyses, customer communications systems analyses, test coordination and conduct, and other customer support services in support of Space Shuttle, International Space Station (ISS) and other human space flight efforts.